The Role of Sleep During the Transition to Kindergarten and Early Academic Achievement

by

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ABSTRACT

The present study tested 1) whether children's bedtimes, wake times, and sleep durations change as they transition into kindergarten (TtoK), 2) if changes to children's sleep schedules were contingent on their pre-kindergarten (T1) napping status and if T1 bedtimes were related to fall (T2) and spring (T3) bedtimes and durations, and 3) whether T1 sleep, changes to sleep from T1 to T2, and concurrent sleep quality were related to academic achievement and participation in 51 kindergarteners. It was hypothesized that 1) wake times would be earlier and sleep duration would be shorter during kindergarten (T2 and T3) than at T1, 2) children who napped at T1 would go to bed later and have shorter sleep duration than their non-napping peers and T1 bedtimes would be positively associated with T2 and T3 bedtimes and negatively associated with T2 and T3 durations, and 3) more optimal sleep (e.g., consolidated, consistent, and high quality) would be positively related to academic achievement and participation. Parents reported on children's bedtimes, wake times, and nap lengths during T1, T2, and T3. During T3 children wore actigraphs for five consecutive school nights and completed the Woodcock Johnson tests of achievement (WJ-III). Teachers also reported on children's participation in the classroom during T3. Results demonstrated that bedtimes and wake times were earlier at T2 and T3 than T1. Duration was shorter at T2 and T3 than T1. Additionally, napping was unrelated to bedtimes and durations, but T1 bedtime was positively related to T2 and T3 bedtimes and negatively related to T2 and T3 durations. Finally, T1 nap length, change in bedtimes, and Actigraphy duration were negatively related to participation. Actigraphy onset variability was positively related to participation.

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Introduction

Over the last decade children have consistently obtained less sleep than recommended by pediatric sleep experts (Matricciani, Olds, Blunden, Rigney, & Williams, 2012; National Sleep Foundation, 2004). Behavioral sleep problems, such as bedtime resistance and night awakenings, are common (20-30%) in early childhood, which may further increase the number of children who obtain inadequate sleep (Mindell, Meltzer, Carskadon, & Chervin, 2009; Mindell, Telofski, Wiegand, & Kurtz, 2009). The United States has the highest percentage of sleep-deprived children across the globe. Recent studies demonstrate that children's sleep deprivation limits teacher's ability to teach appropriate grade-level material (Mullis, Martin, Foy, & Arora, 2012; Mullis, Martin, Foy, & Drucker, 2012; Mullis, Martin, Foy, & Stanco, 2012). A child's inability to get sufficient sleep is especially concerning because inadequate sleep during childhood and adolescence has been related to emotion dysregulation, declines in cognitive functioning, behavior problems, inattention to tasks, and poor academic performance (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Dahl, 1996; Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012; Hatzinger et al., 2010; Wolfson & Carskadon, 1998). Additionally, few studies to date have utilized objective measures of sleep when examining the association between sleep and academic achievement and participation during the TtoK. Therefore, the goal of the present study was to identify if changes to children's sleep patterns occurred as they TtoK and to test if sleep changes and objectively measured sleep quality were related to early academic achievement and participation.

To fully appreciate how sleep relates to children's daytime functioning and subsequent academic achievement and participation, it is valuable to understand the development of sleep during the first five years of life. From infancy to early childhood a mean of approximately 11 hours of sleep per night remains relatively constant (Iglowstein, Jenni, Molinari, & Largo, 2003). Decreases in children's total sleep from infancy to early childhood can be accounted for by fewer and shorter daytime naps (Iglowstein et al., 2003; Weissbluth, 1995). By three years of age almost all children reduce their sleep to a biphasic sleep schedule, with one shorter sleep period during the day (i.e., nap) and one longer sleep period at night (Weissbluth, 1995). Although research is lacking on napping in kindergarteners, 27% of five year olds continue to nap five to seven days a week (Weissbluth, 1995) and the majority of children entering into kindergarten are five years of age (Ramey & Ramey, 1999).

The consolidation of sleep into one nighttime phase has been associated with more mature sleep-wake cycles and more optimal sleep (Lam, Mahone, Mason, & Scharf, 2011; Thorpe et al., 2015). The maturation of sleep may be particularly important for children entering into kindergarten. Preschool and kindergarten children who nap tend to have a circadian preference for later bedtimes (Fukuda & Asaoka, 2004; Lam et al., 2011; Thorpe et al., 2015), which is predictive of shorter nighttime sleep durations (Lam et al., 2011). Furthermore, children who napped in the year preceding formal schooling tended to go to bed later than their non-napping peers in first, second, third, fourth, and fifth grade (Fukuda & Asaoka, 2004). Thus, pre-kindergarten napping may be predictive of shorter sleep duration and subsequently effect daytime functioning.

Scholars have theorized on the importance of sleep for children's daytime functioning. More specifically, the present study was guided by Dahl's (1996) model of "Sleep, Sleep Deprivation, and Prefrontal Cortex Functions" (p. 48). Dahl (1996) draws direct linkages between sleep deprivation and deficits in prefrontal cortex functioning. He argues that non-optimal prefrontal cortex functioning hinders goal-directed and effortful behaviors, which impair cognitive performance, emotion regulation, and social functioning (Yoo, Gujar, Hu, Jolesz, & Walker, 2007; Yoo, Hu, Gujar, Jolesz, & Walker, 2007). In fact, in adults, sleep loss and deprivation sever the neurological pathways between the medial prefrontal cortex and the amygdala, which increases the likelihood of negative emotionality and reduces the ability to effectively consolidate memories (Walker, 2009). Arguably sleep is a key biological function that facilitates early education because it modulates cognition, emotion regulation, and social functioning (Walker, 2009; Yoo, Hu, et al., 2007, 2007), all of which are important skills that children need for academic success (Blair, 2002; Eisenberg, Sadovsky, & Spinrad, 2005; Gruber et al., 2012; Ladd, Birch, & Buhs, 1999).

An examination of children's sleep during the entry into formal schooling may be particularly important. The transition into formal schooling and early educational experiences coincide with a developmental shift in children's sleep schedules, specifically earlier wake times and loss of a daytime nap (Cairns & Harsh, 2013; Kieckhefer, Ward, Tsai, & Lentz, 2008; Weissbluth, 1995). Scholars have long noted the significance of early educational experiences because they are indicative of later academic achievement and future job success (Belsky & MacKinnon, 1994; Entwisle & Alexander, 1993; Lee, 2010; Pianta & Cox, 1999; Pianta & Kraft-Sayre, 2003). Although research signifies that sleep is related to indices of academic success (Gruber, Wiebe, Wells, Cassoff, & Monson, 2010), sleep has been largely understudied during children's early educational experiences.

The following discussion focuses on the TtoK as a sensitive period, how the TtoK is related to sleep, and how sleep relates to academic achievement and participation.

The TtoK: A Sensitive Period

Developmental transitions have often been characterized by shifts in neurological, biological, and ecological processes (Sameroff & Haith, 1996). Due to the substantial shift in various developmental domains, transition periods provide optimal opportunities to study the mechanisms through which developmental milestones are met and, as a result, how developmental processes give rise to social and academic outcomes (Sameroff & Haith, 1996). Given the substantial shifts that take place during the TtoK, it is particularly important to understand how underlying mechanisms, such as sleep, may also change during this period.

Since the 1980s scholars and educators have recognized children's entry into formal schooling as an important and sensitive developmental period (Cowen, Cowen, Ablow, Johnson, & Measelle, 2005; Entwisle & Alexander, 1993; Pianta & Cox, 1999). The TtoK may be highly influential in determining children's academic trajectories. A child's initial behavior and academic success shapes his or her educational identity, which may influence the behavioral and academic expectations of peers and teachers and subsequently transcend through his or her academic career (Belsky & MacKinnon, 1994; Entwisle & Alexander, 1993; Ladd & Dinella, 2009).

As children TtoK, they may experience substantial changes to their expectable environment at school and at home. At school, children may need to learn how to traverse new social relationships with unfamiliar peers, teachers, and school staff (Belsky & MacKinnon, 1994; Cowen et al., 2005), be alert and attentive for long periods of time (Cowen, Cowan, Schulz, & Heming, 1994; Rimm-Kaufman & Pianta, 2000), and adhere to new rules and routines (Rimm-Kaufman & Pianta, 2000). At home, children may need to adjust to new family-based routines, especially those related to their bedtime and wake time (Kraft-Sayre & Pianta, 2000; Wildenger, McIntyre, Fiese, & Eckert, 2008).

Some children may struggle to succeed academically because of the changes to their expectable environment during the TtoK. Children tend to behave better when their daily home routines, such as the sequence of bedtime activities, bedtime, and wake time, are consistent and predictable (Sytsma, Kelley, & Wymer, 2001). Furthermore, research demonstrates that greater changes to children's environment during the TtoK were associated with elevated cortisol levels, indicating a significant amount of stress (Quas, Murowchick, Bensadoun, & Boyce, 2002).

Sleep and the TtoK

School may be a contextual catalyst for change in daily home routines. Research has found that kindergarteners' wake times are approximately an hour before school starts and are highly correlated with school start times (Werner, Molinari, Guyer, & Jenni, 2008). However, school start times may not be consistent with children's wake times prior to kindergarten (Cairns & Harsh, 2013). Further, full-day kindergarten programs may not offer a nap opportunity, meaning that the 27% of five year olds who nap prior to starting kindergarten may need to adjust to a day without a nap (Cairns & Harsh, 2013;

Weissbluth, 1995). To my knowledge, one study to date has examined the changes to children's sleep during the TtoK. Cairns and Harsh (2013) found a significant decrease (30 to 40 minutes) in total sleep duration and significant changes in children's sleep-wake patterns during the TtoK (Cairns & Harsh, 2013). Both children who did and did not attend preschool experienced changes in their sleep-wake patterns; however, the changes were more apparent for children who did not attend preschool (Cairns & Harsh, 2013). As Cairns and Harsh (2013) stated, the children in their sample did not obtain the recommended amount of sleep during the summer and this disparity increased upon the entry into kindergarten.

Although there are individual differences in sleep needs, scholars agree that children who obtain insufficient sleep are more likely to have daytime functioning difficulties (e.g., Dahl, 1996; Dahl & Harvey, 2007; Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012; Iglowstein, Jenni, Molinari, & Largo, 2003; Vriend et al., 2012). Early school age children whose bedtimes and wake times are more inconsistent tend to obtain fewer hours of sleep and have more sleep and behavior problems than children whose sleep schedules are consistent (Mindell, Meltzer, et al., 2009; Mindell, Telofski, et al., 2009; Yokomaku et al., 2008). Because daytime functioning is related to children's sleep, it is reasonable to conclude that insufficient or inconsistent sleep may be related to children's academic achievement and participation. The National Center for Education Statistics (1993) found that teachers rank being "physically healthy, rested, and well-nourished" as the most important characteristics for children's school readiness (as cited in Pianta & Cox, 1999, p. 45). The weight that teachers place on children's health and rest implies that sleep duration and consistency could be a significant predictor of children's success as they

TtoK. Few studies have examined if the entry into formal schooling alters children's sleep-wake schedules and no studies to date have identified if these modifications are related to children's academic achievement and participation in kindergarten.

Sleep and Academic Achievement

Sleep is linked with processes that are important for academic achievement (Gruber et al., 2010). In the well-established literature on adults, sleep deprivation or shorter sleep duration has been associated with diminished daytime functioning, particularly difficulty regulating emotions, sustaining attention, and memory consolidation (e.g., Franzen, Siegle, & Buysse, 2008; Mander et al., 2008; Walker & Harvey, 2010; Walker & Stickgold, 2004; Zohar, Tzischinsky, Epstein, & Lavie, 2005). Limited research on school age children suggests that sleep loss and disruption are related to inattention, increased negative emotions, decreased positive emotions, and trouble modulating behavior (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Dahl, 1996; Epstein, Chillag, & Lavie, 1998; Hatzinger et al., 2010; Vriend et al., 2012), all of which are believed to be central for children's academic success (Gruber et al., 2010).

The majority of the research conducted examining sleep and its relation to academic success in grade school focuses on adolescent populations (e.g., Beebe, Rose, & Amin, 2010; Wolfson & Carskadon, 1998). Some studies have found linkages between sleep and indices of learning and academic success in preschool and school age children. Studies using subjective reports of children's sleep found that indicators of less optimal sleep (e.g., shorter nighttime sleep duration, variability in sleep duration and bedtime, difficulty waking up, and time spent in bed) and sleep problems (e.g., bedtime resistance, sleep apnea, and frequent nighttime awakenings) are predictive of fewer gains in literacy skills, difficulty with school adjustment, and lower academic performance (BaHammam, Al-Faris, Shaikh, & Saeed, 2006; Bates, Viken, Alexander, Beyers, & Stockton, 2002; Molfese, Beswick, Molnar, Jacobi-Vessels, & Gozal, 2009).

Previous literature has helped establish connections between sleep and academic success in early grade school; nevertheless, few scholars have used both subjective and objective measures of sleep. The infrequent use of objective measures in conjunction with subjective reports of sleep is a key limitation of this line of research because subjective reports of sleep tend to underestimate the amount of time spent awake at night (Tremaine, Dorrian, & Blunden, 2010). Objective measures of sleep are better at estimating sleep quality (Ancoli-Israel et al., 2003; Werner et al., 2008), which may be related to academic achievement and participation.

Some examinations of the association between children's sleep and academic achievement have included objective measures (i.e., actigraphy) of sleep. Children who were retained in kindergarten because of some combination of low marks on teacher evaluations, math, reading, and writing achievement tests, were more likely to have longer sleep latency, more night awakenings, and less efficient sleep as measured by actigraphy (Ravid, Afek, Suraiya, Shahar, & Pillar, 2009). In a follow-up study, first graders who had poorer sleep were more likely to get lower marks on achievement tests and worse evaluations from teachers (Ravid, Afek, Suraiya, Shahar, & Pillar, 2009). One study experimentally manipulated children's sleep during a school week and found that when children's sleep was restricted by approximately two and a half hours per night, teachers reported significantly more academic and behavior problems (Fallone, Acebo, Seifer, & Carskadon, 2005). These more rigorous examinations have drawn linkages between sleep and academic achievement. However, scant research exists that specifically examines whether changes to sleep patterns during the TtoK and sleep quality are predictive of objective and subjective reports of academic achievement.

Sleep and Participation

Scholars have increasingly become interested in studying predictors of children's classroom participation (henceforth referred to as participation) because it is related to school readiness and academic success (Fredricks, Blumenfeld, & Paris, 2004; Ladd et al., 1999; Ladd & Dinella, 2009; Murray & Harrison, 2011; Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). In the literature, participation is conceptualized as the behavioral component of school engagement and encompasses children's self-motivated involvement in the classroom and adherence to rules and classroom norms (Fredricks et al., 2004). Given Dahl's (1996) argument that sleep deficits hinder goal-directed behavior and regulatory capacities, it may be that decrements to children's sleep are related to less classroom participation.

Currently, little research exists linking sleep with children's participation in the classroom. Meijer (2008) found that adolescents who reported that they were chronically sleep deprived were also more likely to report that they had less motivation to achieve in school. Brown and Low (2008) found that in preschool children, parent-reported sleep problems were positively related to helpless responses to academic challenge. This study advances this line of research by examining the association of participation with sleep in pre-kindergarten, change in sleep across the TtoK, and objectively measured sleep quantity and quality.

The Present Study

The purpose of the present study is to gain a fuller understanding of the changes to children's sleep during the TtoK and if the changes are related to early academic achievement and participation.

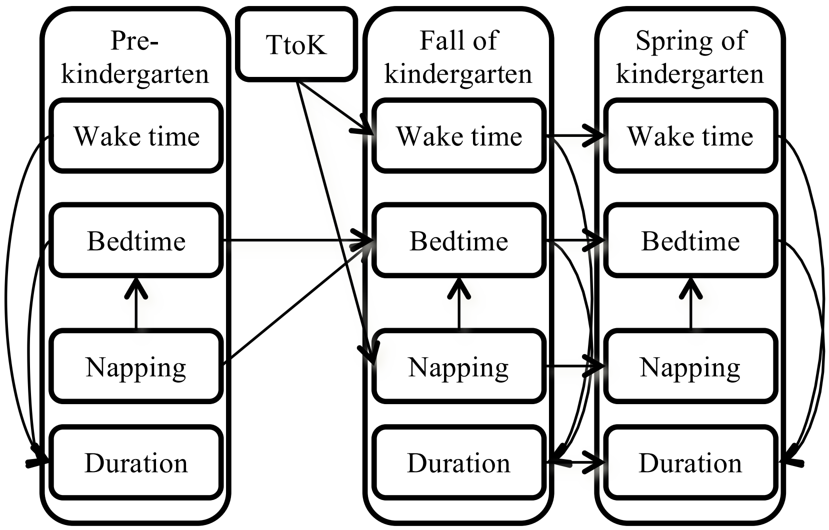

Figure 1. Heuristic of hypothesis 1 and 2

Children's sleep may change during the TtoK because of individual developmental characteristics, such as changes in neurological and cognitive functioning, or contextual factors, such as school start times and the lack of an opportunity to nap during the day (Weissbluth, 1995; Werner et al., 2008). Although the entry into formal schooling may be a contextual factor that has the ability to change children's sleep-wake schedules only one study to date has examined these changes (Cairns & Harsh, 2013). Therefore, the present study first identified if there were changes to children's sleep during the TtoK by examining sleep at three time points: one month prior to kindergarten (T1), the fall of kindergarten (T2), and spring of kindergarten (T3). This examination focused on the changes to bedtimes, wake times, nap length, and sleep duration because they are the most likely to change due to the timing of a formal school day (see Figure 1).

Literature specifically examining sleep and academic achievement in kindergarten is scarce; however, previous research with school-age children suggested that more optimal sleep patterns and habits are more likely to result in better academic performance (see review Gruber et al., 2010). Furthermore, it is unknown whether changes to children's sleep-wake schedules during the TtoK are related to early indices of academic achievement. Therefore, the present study examined whether the changes to sleep-wake patterns, sleep quality, and consistency of sleep were related to early academic achievement and participation (see Figure 2; see below for specific hypotheses).

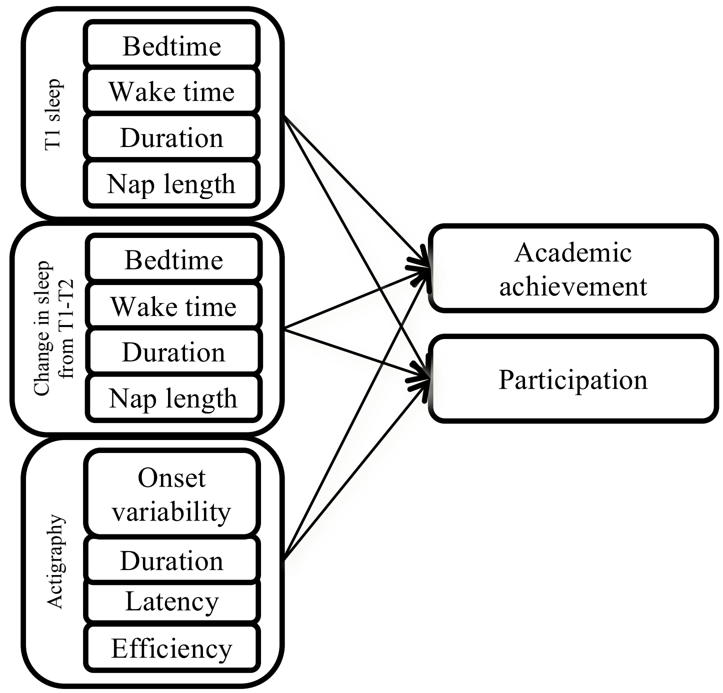

Figure 2. Heuristic of hypothesis 3. T1=Pre-kindergarten. T2= Fall of kindergarten

Previous examinations of sleep and academic achievement have included either objective measures of sleep *or* academic achievement, but have not, to my knowledge, included both. Although subjective sleep data (e.g., parent reported sleep diary data) can be useful for detecting sleep onset and offset, they lack the ability to give information about nighttime awakenings and sleep onset latency (Werner et al., 2008). Polysomnography (PSG) and observation are considered the 'gold standards' for collecting sleep-wake data (Meltzer, Montgomery-Downs, Insana, & Walsh, 2012); however, PSG and observation are both costly and invasive measures. Actigraphy provides a discreet and naturalistic means for collecting sleep-wake data (Ancoli-Israel et al., 2003; Meltzer et al., 2012). Actigraphy has been validated against PSG with high agreement rates (80%-90%) in several studies for use with children and adults (Acebo et al., 1999; Ancoli-Israel et al., 2003; Meltzer et al., 2012; A Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991). Thus, the present study identified which sleep-wake patterns and habits were related to academic achievement by using subjective and objective measures of both sleep and academic achievement and participation.

Hypotheses. Based on previous research, it was hypothesized that (1) children's sleep schedules would change (earlier wake times and shorter sleep duration) upon the entry into kindergarten, (2) children who were napping and/or went to bed later at T1 would be more likely to go to bed later and have shorter nighttime sleep durations at T2 and T3 of kindergarten than their peers who did not nap and/or who went to bed earlier, and (3) fewer sleep schedule changes and optimal sleep patterns (e.g., more consistent, monophasic, earlier bedtimes, longer sleep duration, less variable onset, shorter latency, and more efficiency) would be positively related to academic achievement on standardized tests and participation as rated by teachers.

Method

Participants

The sample for this study was recruited from an ongoing longitudinal study. Participants for the larger longitudinal study were recruited from five public elementary schools in a southwestern U.S. city. Caregivers (*N*=215) were presented with materials about enrollment and participation in the study. Study staff was available to answer caregivers' questions during two school events, "meet the teacher" and "curriculum night," that took place before the academic year began. Participating teachers (*N*=11) from the 11 original regular education classrooms were also encouraged to receive a response (either yes or no) from the majority of the caregivers in their classroom. Children were excluded from participating in the study if their sibling was already enrolled in the project. Because of the longitudinal nature of the study, if children moved they were followed to other elementary schools. A total of 11 teachers participated in the present study.

Participants for the present study were recruited from the original sample (*n* = 123) through phone calls and mailings. Parents of 51 kindergarteners (50% male) provided consent for themselves and children provided assent. On average, kindergarteners were 5.43 years old (*SD* = 0.29) at T2. Participating children were 50.9% Hispanic (80.8% White/Hispanic, 11.5% Black/Hispanic, and 7.7% Other/Hispanic), 39.2% White, 3.9% American Indian, 2% Asian, 2% African American, and 2% Other. Hispanic children had at least one parent who predominantly self-identified as Mexican or Mexican American (52.2%). Children typically were from two-parent homes (67.3%), in which the primary caregiver was the child's biological mother (84.3%, 3.9% biological fathers, 2.0% step mothers, 3.9% other, and 5.9% unreported). The mean reported family income range was $60,000-$69,999 and ranged from $0-$9,999 to $100,000 or over. Of the primary caregivers 2.0% had not obtained a high school diploma, 9.8% had a high school diploma or some equivalent, 23.6% had some college education, 13.7% had an associates degree or completed trade school, 23.5% had a bachelors degree, and 11.8% had a masters degree, 7.8% had a doctorate degree, and 7.8% were unreported.

To examine differences between children who were only enrolled in the larger study and those who also enrolled in the sleep study, chi-square tests were conducted on gender, race, marital status, primary caregiver's relationship to the child, family income, and primary caregiver's education. If the variable was categorical (i.e., race, marital status, primary caregiver's relationship to the child, family income, and primary caregiver's education), it was dummy coded and then the dummy code was used in the chi-square. Gender, race, marital status, family income range, and primary caregiver's education were not significantly different between samples. However, participants in the sleep study had a higher percentage of biological mothers as primary caregivers (84%) as compared to the larger study (60%) (χ^2 (1) = 8.58, *p* = .005). A Fisher's exact test was used to determine if the number of Hispanic children whose parent's self-identified as Mexican American in the present study differed from the larger study. This test was conducted instead of a chi-square because one cell contained less than five participants, which violated the assumption of minimum frequency of five or more participants per cell. The results of the Fisher's exact test revealed a difference that approached conventional levels of significance; Hispanic participants in the sleep study were less likely to have at least one parent self-identify as Mexican American (57%; 12/21) compared to the larger sample (83%; 19/23)(p=.099). Independent samples t-tests found no significant differences between child's age and chaos in the home in the present study and the larger sample.

Procedure

Children's academic skills were assessed at school using subtests from the Woodcock Johnson tests of achievement (i.e., Picture Vocabulary (assessed at T2) and Applied Problems and Passage Comprehension (assessed at T3)). Children received a prize at each assessment. At T3, teachers reported on each participating child's participation in the classroom. Teachers were paid $15 for each questionnaire completed. Caregivers filled out a daily sleep diary using pencil and paper or online. The diary was available in English and Spanish. Children wore an actigraph for five consecutive school days and nights. Caregivers and children were instructed to only take off the actigraph if the child was showering or engaging in activities where the actigraph could be damaged. Caregivers were instructed to give their child a sticker for each day that he or she successfully wore the actigraph. In the present study, caregivers were paid $50 for their time and children were given a prize.

Measures

Sleep during the TtoK. To assess changes in children's sleep during the TtoK a 6-item parent report questionnaire was administered at T2 to get a retrospective report of children's sleep at T1 and a concurrent report at T2. These same questions were administered at T3 for a concurrent report of children's sleep at T3. Previous research demonstrated that parents were able to reliably identify children's bed and wake times (Werner, Molinari, Guyer, & Jenni, 2008). Parents reported on their child's nap length (e.g., "How long was your child's typical nap?") using a select set of responses (0=*Unsure of duration*, 1= *15 minutes*, 2= *30 minutes*, 3= *45 minutes*, 4= *45 minutes*, 5= *1 hour*, "if longer than an hour please write in your child's typical nap length"). Parents reported on their child's bedtimes and wake times using a free response format. Duration was calculated as the difference between bedtime and wake time. In this study, duration refers only to nighttime sleep and did not include naps. These items are similar to those used in the Children's Sleep Habits Questionnaire, which has worked well in elementary school samples (Owens, Spirito, McGuinn, & Nobile, 2000). See the Appendix for the exact items used in this questionnaire.

Actrigraphy. During T3 children wore actigraphs (Actiwatch 2 ®; Philips Respironics Inc, Murrysville, PA, USA) on their non-dominant wrist for five consecutive school days. Data used in this study were from school nights starting Sunday night and ending Thursday night. The actigraph continuously measured motion using a piezoelectric accelerometer, allowing the detection of sleep/wake states (Weiss, Johnson, Berger, & Redline, 2010). Actigraphs were set to collect data in 1-minute epochs at medium sensitivity (40). Data were downloaded and scored using Actiware V5.7 (*Actiware*, 2012), which generated activity scores for each epoch by calculating a weighted average of the current and surrounding epochs ($\pm$ 2 minutes) (Weiss et al., 2010). Actigrams were scored for sleep start and end times using a parent-reported sleep diary. Actiware estimated sleep start and end times if diary data were not available. Four measures from Actiware were included in this study: onset, duration, latency, and sleep efficiency. Average duration, latency, and efficiency were calculated as a mean of at least three nights of sleep (Acebo et al., 1999). Onset variability was calculated as the within-person standard deviation of onset using at least three nights of sleep. Actigraphy has been established as a valid and non-invasive tool for measuring sleep/wake behavior in naturalistic settings with young children (Acebo et al., 1999; Sadeh, Sharkey, & Carskadon, 1994).

Academic achievement. Children completed the Picture Vocabulary subtest from the Woodcock Johnson III Tests of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001) during T2. At T3, children completed the Applied Problems and Passage Comprehension subtests from the WJ-III. These standardized tests have been appropriate for assessing intellectual abilities in individuals ranging from 2 to 90 years of age. *W* scores from these subtests were used in the analyses for the present study. *W* scores, which are similar to standardized scores, were computed from raw scores using the WJ-III software. The *W* score allows for a comparison with a normative population based on a score provided by the WJ-III. The Applied Problems and Passage Comprehension subtests were highly correlated ($r = .61$, $p < .001$); therefore, for parsimony these subtests were averaged to create a WJ composite.

Participation. At T3, children's participation was assessed with teachers' reports on the School Liking Avoidance and Participation Questionnaire (Ladd & Price, 1987). Teachers reported on items from the Children's Cooperation in the Classroom (e.g., "follows a teacher's direction," "responds promptly to teacher's requests") and Ability to Independently Participate subscales (e.g., "seeks challenges," "works independently") on a 3-point scale (0 = *doesn't apply* to 2 = *certainly applies*). The items in the cooperation and independent participation subscales demonstrated high inter-item reliability ($\alpha = .91$ and $\alpha = .80$; respectively; Ladd & Price, 1987).

Controls. Parents reported on children's Hispanic ethnicity (0 = *non-Hispanic*, 1 = *Hispanic*), socioeconomic status, age, and any mediation that may have potentially affected their sleep. Family income, mother's education, and father's education (when available) were z-scored and then the average was used as socioeconomic status. Age was calculated by taking the difference between the first day of school and the child's date of birth. Parents reported children's medication use during the five days that the child wore the actigraph. A proportion of the number of days that the child took potentially sleep-altering medication was used in this study.

Results

Preliminary Analyses

Prior to hypothesis testing, descriptives were examined for the means, standard deviations, and distributions of all study variables (see Table 1). T1 and T2 nap lengths were not normally distributed. Approximately 30% of the children were napping upon entering kindergarten; therefore, most children's nap length was zero. A log transformation was performed on these variables and the transformed scores were used when testing the hypotheses.

Next, frequencies were examined to determine if the proportion of nappers at T1 was similar to percentages reported in previous literature. Similar to previous studies (e.g., Acebo et al., 2005; Crosby, LeBourgeois, & Harsh, 2005; Weissbluth, 1995), at T1 66.7% of children did not nap, 29.4% napped, and 3.9% of parents responded "I don't know" or had not responded. These results provided enough support to test the second hypothesis.

Finally, zero-order relations amongst the study variable were examined (see Table 2). Several sleep variables were significantly associated with other sleep variables. In order to keep this discussion succinct, only the correlations pertinent to the proposed hypotheses are presented here. To understand the associations between T1, T2, and T3 sleep schedule variables used to test the first hypothesis, correlations amongst the parent-reported sleep schedule variables were examined. Children who went to bed later at T1 were also likely to go to bed later at T2 and T3. T1 wake times were unrelated to T2 and T3 wake times; however, children who woke up earlier at T2 were more likely to wake up earlier at T3. T1 duration was unrelated to T2 and T3 duration, however, children who had longer duration at T2 were more likely to have longer duration at T3. Actigraphy duration was positively related to T2 and T3 parent reported sleep duration.

To help clarify the changes to children's sleep schedules as a function of the TtoK, correlations were also examined between parent-reported wake times and durations. Children who woke up later at T1 were more likely to have longer sleep duration at T1, but shorter sleep duration at T2 and T3. Children who woke up later at T2 were more likely to have longer sleep duration at T2, but not at T3. To explore the associations postulated in hypothesis two, correlations between nap lengths and other sleep schedule variables were examined. T1 nap length was not related to other sleep variables. Children who had longer naps at T2 were more likely to go to bed later at T1, T2, and T3, wake up later at T1, and have shorter sleep duration at T2 and T3.

There was some evidence to support hypothesis (see Table 3). Children who had higher scores on the WJ-III composite were more likely to go to bed earlier at T3[1], wake up earlier at T1[1], have shorter naps at T2, have longer parent-reported sleep duration at T3 and longer actigraphy measured latency[1]. Children who cooperated more in the classroom were more likely to have shorter T1 naps[1] and longer actigraphy measured latency. Children who independently participated were more likely to have shorter T1 naps[1], later bedtimes at T2 than predicted by their T1 bedtime[1], more actigraphy measured sleep onset variability and longer latency [1].

Do Children's Sleep Schedules Change as They Enter into Kindergarten?

To test the hypothesis that children's sleep schedules would change upon entering into kindergarten, three repeated measures ANOVAs were conducted with parent-reported bedtimes, wake times, and duration as the dependent variable. Time (i.e., T1, T2, and T3) was specified as the within-subjects factor. Also, the interaction between change in sleep and socioeconomic status was examined; however, this interaction was not significant. Therefore, the interaction was not included in the final models. As shown in Table 4, the multivariate test was significant for bedtimes, wake times, and duration. Post hoc tests were conducted using the Tukey LSD correction with a modified Shaffer, to control for Type I error across the pairwise tests. Pairwise tests revealed that children's bedtimes were significantly earlier at T2 and T3 than T1. However, there was not a significant change in bedtimes from T2 to T3. Children's wake times were significantly earlier at T2 and T3 than T1. Again, there was not a significant change in wake times from the T2 to T3. Children's sleep duration was less at T2 and T3 than T1. Consistent with the previously reported pairwise tests, there was not a significant change in children's sleep duration from T2 to T3.

Relations Between Children's Pre-Kindergarten Napping Status or Bedtime and Changes to Children's Sleep Schedules as They Entered into Kindergarten

To test the second hypothesis, two repeated measures ANOVAs were conducted with bedtimes and duration as the dependent variable. Pre-kindergarten napping status, yes or no, was the between-subjects factor. Time (i.e., T1, T2, and T3) was specified as the within-subjects factor. A multivariate *F* test found that napping status was not a predictor of children's parent-reported bedtimes or sleep duration from T1 to T3 ($F(2,45) = 0.28$, $p = 0.76$; $F(2,45) = 0.07$, $p = 0.93$; respectively). Also, the interaction with socioeconomic status was examined; however, this interaction was not significant. Due to null results, no post hoc tests were conducted.

To test whether T1 bedtime was related to children's parent-reported bedtimes and sleep durations at T2 and T3, regressions controlling for Hispanic ethnicity, socioeconomic status, age, and sleep medication taken during sleep data collection were conducted predicting T2 and T3 bedtimes and sleep durations from T1 bedtime. Results supported the hypothesis that children's T1 bedtime was related to their bedtimes and sleep durations at T2 and T3. T1 bedtime was positively related to T2 and T3 bedtime ($\beta = 0.65$, *S.E.* = 0.07, $p<0.001$, $\beta = 0.54$, *S.E.* = 0.08, $p = 0.001$; respectively). T1 bedtime was negatively related to T2 and T3 sleep duration ($\beta = -0.56$, *S.E.* = 0.07, $p = 0.001$, $\beta = -0.42$, *S.E.* = 0.07, $p = 0.010$; respectively).

Relations Between Children's Sleep During the Transition into and During Kindergarten and Academic Achievement and Participation

To test the third hypothesis, I ran a series of regressions predicting children's early academic achievement and participation from parent-reported sleep schedules and actigraphy. The first set of regressions examined whether children's sleep schedules at T1 were related to early academic achievement and participation. In these regressions the T1 sleep schedule variables were included in the second step as the focal predictor after the controls (see Table 5). As shown in Table 5, parent-reported T1 nap length was negatively related to cooperation in the classroom[1]. There were no significant relations between T1 bedtime, T1 wake time, or T1 duration and the academic outcomes.

The second set of regressions examined the change in children's sleep schedules (i.e., bedtime, wake time, duration, and nap length) from T1 to T2 in predicting early academic achievement and participation. In these regressions, a standardized residual change score, calculated from a regression predicting the T2 sleep schedule variable from the T1 sleep schedule variable, was included in the second step as the focal predictor after the controls (see Table 6). As shown in Table 6, change in bedtime was negatively related to children's ability to independently participate. Changes in wake time, duration, and nap length were unrelated to children's early academic achievement and participation.

The final set of regressions examined the relation between objectively measured sleep and early academic achievement and participation. In these regressions an actigraphy variable was included in the second step as the focal predictor after controls (see Table 7). As shown in Table 7, onset variability was positively associated with children's cooperation in the classroom and ability to independently participate. Additionally, duration was positively associated with children's ability to independently participate. All other models including objectively measured sleep variables were not significant.

The positive association between onset variability and participation was unexpected because high variability in sleep is generally considered non-optimal and related to poorer academic outcomes (Sarit Ravid et al., 2009). Previous studies have also found that children from Hispanic families tend to have inconsistent bedtimes (Hale, Berger, LeBourgeois, & Brooks-Gunn, 2009). Therefore, I chose to explore if Hispanic ethnicity moderated the association between onset variability and participation. An interaction term using Hispanic ethnicity and mean centered onset variability was calculated. Each regression included mean centered onset variability, Hispanic ethnicity, the interaction term, and all mean centered controls (socioeconomic status, age, medication and WJ Picture Vocabulary) (Aiken & West, 1991). The interaction between onset variability and Hispanic ethnicity in predicting cooperation in the classroom was not significant ($\beta = 0.29$, *S.E.* = 0.40, $p = 0.196$). Consequently, simple slopes were not tested for this interaction.

In contrast, the interaction between onset variability and Hispanic ethnicity in predicting ability to independently participate was significant ($\beta = 0.48$, *S.E.*=0.43, $p = 0.021$). Simple slopes were tested for non-Hispanic and Hispanic children. For non-Hispanic children the association between onset variability and independence was not significant ($\beta = 0.06$, *S.E.*= 0.32, $p = 0.770$). For Hispanic children there was a significant positive association between onset variability and independence ($\beta = 0.71$, *S.E.*= 0.30, $p = 0.001$; see Figure 3).

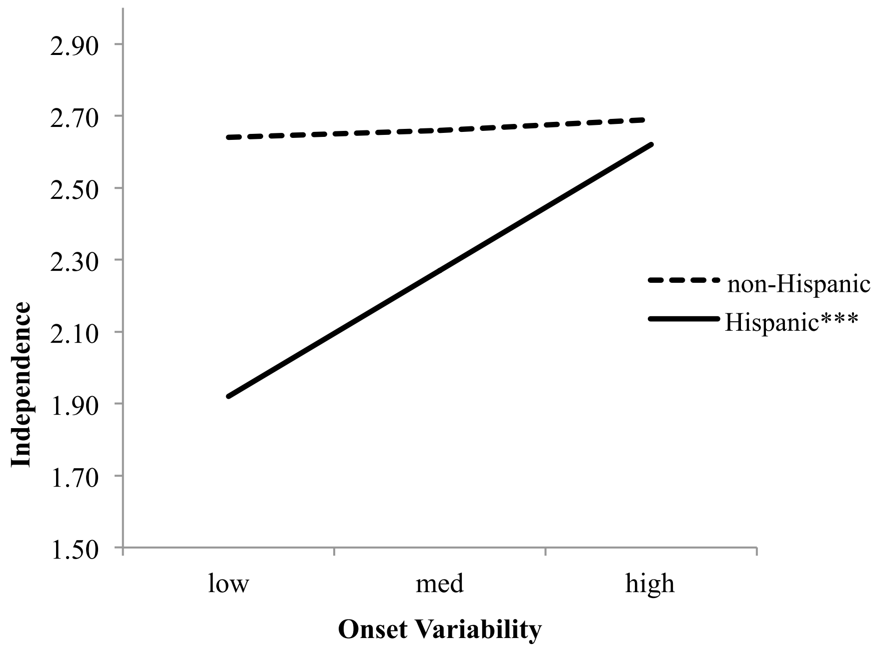

Figure 3. Association between onset variability and independence as moderated by Hispanic ethnicity. ***p<.001.

Discussion

The purpose of this study was to fill a gap in the literature on children's sleep and academic success during the TtoK. Over the last thirty years there have been substantial research efforts aimed at gaining a better understanding of the predictors of successful adjustment to formal schooling (e.g., Entwisle & Alexander, 1993; LoCasale-Crouch, Mashburn, Downer, & Pianta, 2008; Pianta & Cox, 1999). Empirical examinations continually demonstrate that sleep is related to daytime functioning (e.g., Gruber, Wiebe, Wells, Cassoff, & Monson, 2010), but sleep has rarely been examined in reference to early education or the TtoK. Furthermore, to my knowledge, scholars have not examined whether changes to children's sleep during the TtoK relate to academic achievement and participation. Therefore, the goals of this study were to 1) test if children's sleep schedules change as they TtoK, 2) explore whether sleep schedule changes were related to napping, and 3) examine if T1 sleep, changes to sleep, and objectively measured sleep were related to academic achievement and participation in kindergarten.

Changes to Children's Sleep Across the TtoK

Consistent with the first hypothesis, the data demonstrated that children woke up earlier and had shorter sleep durations at T2 and T3 than at T1. Additionally, children went to bed earlier at T2 and T3 than at T1. As children transitioned into kindergarten their parent-reported sleep duration significantly decreased by an average of 28 minutes (see Table 4). Reductions in sleep duration during the TtoK appeared to primarily be a function of the change in children's wake times. Children in this sample went to bed approximately 26 minutes earlier, but woke up approximately 54 minutes earlier during kindergarten (Table 4). These findings are consistent with one other previous examination (Cairns & Harsh, 2013).

The change in sleep schedules may be because children need to wake up early to arrive at school on time. School start times in this sample ranged from 7:15 AM to 8:15 AM. Werner and colleagues (2008) found that children generally wake up about an hour before school. This seems to be true in the current study as well, as children woke up anywhere from 6:00 AM to 10:30 AM at T1 but woke up between 5:30 AM and 7:15 AM at T2 and T3 (Table 1). Future studies are needed to further understand the contextual factors related to school start time that may be related to changes in children's sleep during the TtoK.

Sleep experts suggest that children in this age group should be obtaining at least 11 to 12 hours of sleep per night (Meltzer & Mindell, 2006). However, children in this sample slept approximately 10 hours and 40 minutes at T1, which is consistent with previous examinations of children's sleep in this age group (Christine Acebo et al., 2005; Cairns & Harsh, 2013). Given that children were obtaining less sleep than recommended, a half hour reduction in sleep duration during kindergarten may be problematic.

Additional studies are needed to better understand the mechanisms through which children's sleep changes across the TtoK. Although this study was able to detect effects with parent-reported sleep schedules, more multi-method and longitudinal studies are needed that examine the change in children's sleep across the TtoK. Scholars who study the TtoK have identified ages 4 to 7 as a critical transition period (Pianta & Cox, 1999; Pianta & Rimm-Kaufman, 2006; Rimm-Kaufman & Pianta, 2000); therefore studies examining sleep across this more prolonged period are needed. A longer longitudinal investigation, starting at least six months prior to kindergarten and through the end of the first grade year, including more objective measures of sleep during the TtoK could advance this line of research and enhance transition practices.

Associations Between Pre-Kindergarten Napping or Bedtimes and Kindergarten Sleep

Results partially supported the second hypothesis. Although the change in children's parent-reported bedtimes and durations across the TtoK was not related to children's T1 napping status, children who had later bedtimes at T1 were more likely to have later bedtimes and shorter sleep duration at T2 and T3.

It was hypothesized that children who napped at T1 would have later bed times and shorter sleep durations across the TtoK. Although the proportion of nappers to non-nappers was consistent with previous examinations (Table 1; Acebo et al., 2005; Cairns & Harsh, 2013; Crosby, LeBourgeois, & Harsh, 2005), statistically significant differences in bedtimes and durations between T1 nappers and non-nappers were not detected. Further, T1 nap length was not associated with T1, T2, or T3 bedtimes and durations. These results were incongruent with Fukuda and Asaoka's (2004) study, which found that children who napped in preschool had later bed times and shorter sleep durations across elementary school. Similarly, in a recent review by Thorpe and colleagues (2015) most studies have found that longer naps and later bedtimes were association with shorter duration. The timing of naps during T1 may have been meaningful and may have accounted for why this association was not present in the data.

In this study, napping was measured as napping status and typical nap length. The timing of naps was not measured; however the timing of naps may be related to other sleep parameters. Komada and colleagues (2012) found that children whose nap ended later in the day had a later bedtime that night. While T1 naps were not related to T1 bedtimes and duration, longer T2 nap lengths were related to later T2 bedtimes and shorter sleep duration. Although the timing of T2 naps is unknown, it is likely that children who were napping at T2 were napping after school ended (i.e., between 2:30 PM and 3:00 PM). Given the presence of an association at T2 and not T1, it may be that at T1 children were able to nap earlier in the day and therefore their bedtimes and duration were not effected. Research on napping and its relation to other sleep variables is limited in early school-age children. Future studies are needed to disentangle the associations of other sleep parameters with nap presence, length, and timing.

Results supported the later part of the second hypothesis; later T1 bedtimes were related to later bedtimes and shorter sleep durations at T2 and T3. Children who went to bed later at T1 may have been likely to continue to go to bed later than their peers at T2 and T3 because of family and environmental processes, such as parents' schedules, or individual characteristics, such as circadian preference. Family routines may be based on cultural or contextual factors that may dictate children's bedtimes. For example, in families where parents return home from work later in the evening, the family may eat dinner later, and consequently children may go to bed later (Jenni & O'Connor, 2005). Additionally, cultural differences have been related to parent's beliefs about the use of bedtimes (Crosby et al., 2005; Jenni & O'Connor, 2005). "Bedtime" is not a concept that all cultures ascribe to (Jenni & O'Connor, 2005). Therefore, some children may continue to go to bed later during kindergarten because of family routines that occur later in the evening or because of cultural beliefs that do not emphasize the use of a formal bedtime.

Further, research on social jetlag may explain why later bedtimes at T1 may be related to shorter sleep duration at T2 and T3. In adult and adolescent populations, social jetlag is present when there is a discrepancy between an individual's circadian preference for sleep timing and contextually imposed constraints, such as school and work start times (Roenneberg, Allebrandt, Merrow, & Vetter, 2012; Wittmann, Dinich, Merrow, & Roenneberg, 2006). This misalignment has been demonstrated by shorter duration in "contextually constrained" sleep than "free sleep" opportunities (e.g., weekends) (Roenneberg et al., 2012). In this study results demonstrate higher variability in parent-reported sleep variables at T1. Therefore, T1 may have been a time where there were more "free sleep" opportunities and children may have been able to go to bed at a time that was more aligned with their circadian preference (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998). As previously noted, children were able to shift their bedtimes by approximately a half hour. However, a half hour was not enough as children needed to wake up an hour earlier to get to school on time. This discrepancy resulted in a loss to sleep duration, thus explaining the negative relation between T1 bedtime and T2 and T3 duration. Additional research is required to understand whether social jetlag is present in early school-age children.

Associations of Sleep with Academic Achievement and Participation

The results of this study only partially supported the hypothesis that more optimal sleep would be concurrently and longitudinally related to higher academic achievement and more participation. A negative association between T1 nap length and cooperation was found at a trend level, but there were not significant associations between T1 bedtime, wake time, and duration to academic achievement and participation. There was a negative association between the change in bedtime[1] and independence, but there were not significant associations of the change in wake times, duration, and nap lengths with academic achievement and participation. Results revealed a significant positive association of objective onset variability with cooperation and independence. Additionally, there was a significant positive association between objective sleep duration and independence. However, significant associations of latency and efficiency with academic achievement and participation were not found.

Developmental sleep processes that occur during the TtoK may explain the negative association between T1 nap length and cooperation found in this study. In the developmental literature, optimal adjustment and growth are quantified by the achievement of certain milestones. Sleep consolidation, or the shift from bi-phasic to uni-phasic sleep patterns, is considered to be a more mature and optimal form of sleep (Lam et al., 2011). Sleep consolidation may be an indicator of school readiness. In preschool children, Lam and colleagues (2011) found that longer weekday naps were related to fewer language skills and more impulsivity, both of which are skills that are necessary for school readiness and are related to subsequent classroom cooperation (Blair, 2002; Duncan et al., 2007; Pagani, Fitzpatrick, Archambault, & Janosz, 2010). Therefore, longer naps at T1 may be negatively related to cooperation through school readiness skills. Napping at T1 may point to a lack of maturity and therefore decrements to other school-related skills. Scholars have yet to examine the processes related to the timing of consolidation and how the timing of consolidation may be related to early academic skills. This type of examination may be particularly pertinent to school readiness scholars and may help clarify some of the mechanisms through which children become school ready.

In this sample, children generally went to bed earlier at T2 than at T1. However, the children who went to bed later than expected (i.e., deviation from the regression line) at T2 given their T1 bedtime were less likely to independently participate[1]. Children may need to shift their bedtimes to be earlier to accommodate for earlier wake times during kindergarten. As results of this study demonstrate, children who did not shift their bedtime may have had a harder time adjusting during kindergarten. Nevertheless, going to bed earlier may not be optimal for children whose circadian preference is for later bedtimes (Carskadon et al., 1998). This may be particularly true for children in this study given that T2 wake times were positively related to T2 sleep duration. During the workweek, those who have a circadian preference for later bedtimes were more chronically sleep deprived (Roenneberg et al., 2012). In children, even a small amount of deprivation can be related to non-optimal daytime functioning (Berger et al., 2012; Fallone et al., 2005). More studies are needed to understand whether social jetlag is present in preschool and early elementary school and whether circadian preferences may be indirectly related to school adjustment and success.

Children's objectively measured sleep duration was concurrently and positively related to independent participation in the classroom. The association between sleep duration and children's ability to independently participate may be explained by Dahl's (1996) model and research on sleep and cognition. Dahl (1996) argues that inadequate sleep, which is in part due to short sleep duration, hinders children's ability to be self-motivated to complete a goal through restricted prefrontal cortex functioning (Meijer, 2008). Children who have shorter sleep duration may be less likely to independently participate in the classroom because of low motivation to complete tasks and assignments. Additionally, shorter sleep duration has been linked with lower cognitive functioning (Gruber et al., 2010; Avi Sadeh, Gruber, & Raviv, 2003) and cognitive maturity has been related to participation (including independent participation) (Ladd et al., 1999). Therefore, sleep duration may be related to independent participation through its association with cognitive functioning. Given the concurrent associations found in the present study, it would be beneficial for future studies to examine whether sleep duration is longitudinally predictive of independent participation. Additionally, future studies examining the cognitive mechanisms through which sleep is related to participation could help clarify these relations.

The positive association between onset variability and classroom cooperation and independence was unexpected, as greater variability in sleep is typically related to poorer outcomes (Bates et al., 2002). Previous studies examining parents' beliefs about consistent bedtime use found that parents from ethnic minorities, including Hispanic parents, report inconsistent use of bedtimes and routines (Hale et al., 2009; Milan, Snow, & Belay, 2007). Therefore, the interaction between onset variability and Hispanic ethnicity and its association with independence and cooperation was examined. Hispanic ethnicity did not moderate the association between onset variability and cooperation, but it did moderate the association between onset variability and independence. In fact, the positive association between onset variability and independence was only significant for Hispanic children. The association was not present for non-Hispanic children.

One plausible explanation is that children who are given more autonomy at home, and thus more control over their own bedtimes and routines, may be more likely to have higher motivation to independently participate and cooperate in the classroom (Mattanah, 2005; Ryan & Powelson, 1991). This may be particularly true in Hispanic children. In the United States, some Hispanic children may be given more responsibilities and autonomy, in part because the child needs to help the parent communicate with other adults in English (Dorner, Orellana, & Li-Grining, 2007; Love & Buriel, 2007; Villanueva & Buriel, 2010). Hispanic children who have more autonomy tend to also have better adjustment in adolescence (Sher-Censor, Parke, & Coltrane, 2011). Therefore, among Hispanic children, it is plausible that variability in sleep onset is an indicator of more autonomy at home and thus may be related to more autonomy and independence in the classroom. Future studies are needed to help clarify if the relations between sleep and early academic achievement are similar for Hispanic and non-Hispanic children.

Strengths, Limitations, and Future Directions

This study has several strengths. First, parents reported on children's sleep schedules retrospectively at T1, concurrently at T2 and concurrently at T3. The current study is one of few to be able to demonstrate that children's sleep changes during the TtoK (Cairns & Harsh, 2013). Second, measures of napping were included in this study, and therefore this was the first examination of its kind to examine the function of napping in early elementary school. Third, this study included both objective and subjective measures of sleep. Finally, there is unlikely to be reporter effects present in the current study because the predictors and outcomes were assessed using different reporters or methods.

Despite the methodological strengths this study is not without its limitations. First, in order to test whether children's sleep changed across the TtoK subjective measures of children's sleep schedules were used. Although scholars have demonstrated that parent-reported bedtimes and wake times were typically accurate (Werner et al., 2008), it is preferable to use objective measures to quantify children's sleep. Second, T1 sleep schedule variables were measured retroactively (at the same time as T2) and parents were only queried about the month before kindergarten. Some scholars have suggested that the transition into formal schooling starts at least six months before the first day of school (Pianta & Rimm-Kaufman, 2006). Additionally, children's sleep schedules in the summer may be very different than their sleep schedules during the rest of the year. Future studies are needed in order to examine if some parents try to change children's sleep schedules to fit with imminent school schedules and when these changes occur. Third, participant recruitment was limited to children within the larger study sample. Given the limited population to choose from, the use of more stringent exclusion criteria, such as medication use, was not feasible. Fourth, the small sample size resulted in low statistical power to detect effects.

This study expands the current literature by confirming that children's sleep schedules do change as they TtoK, but that these changes may not be a function of napping. Additionally, results of this study demonstrate that pre-kindergarten napping, changes in bedtimes, and objective and concurrent duration were related to children's participation in school.

The results of this study suggest that school start times might be related to changes in children's sleep. Carskadon and colleagues have extensively studied the effect of school start and end times on adolescents sleep health (e.g., Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998; Wolfson & Carskadon, 1998). This body of research has helped to enact policy changes that enable a better match between adolescent's circadian preferences and school start times. However, there is, to my knowledge, no research on whether young children's circadian preferences. It would be interesting to examine whether children's circadian preferences are related to school start times. Research in this domain may help scholars and policy makers understand whether children's sleep health is related to school start times.

Although circadian preferences have biological and genetic roots (Wittmann et al., 2006), pre-kindergarten might be an optimal time to intervene with children who have a preference for later bedtimes. Interventions have been successful at improving children's sleep by using parent-management training to adjust children's bedtime routines (Mindell et al., 2006; Mindell, 1999). Scholars could enhance this research by utilizing a similar method to prevent sleep loss during the TtoK. Furthermore, intervention research in this area could draw more causal conclusions about changes to children's sleep and other outcomes.

The findings of T1 sleep, change in sleep from T1 to T2 and objectively measured sleep with academic achievement and participation were sparse. Sleep has not been examined in relation to children's participation in the classroom. However, as the results of this study demonstrate it may be important to consider sleep as being potentially related to participation and perhaps other types of engagement.

FOOTNOTES

1. Significance was at a trend level, $p<.10$.

TABLES

Table 1.

Descriptive statistics

	N	Min.	Max.	*M*	*SD*
Parent-reported sleep schedules					
Bedtimes					
T1	49	07:30 PM	01:45 AM	08:47 PM	1:07
T2	49	07:00 PM	09:30 PM	08:22 PM	0:32
T3	51	07:00 PM	10:00 PM	08:24 PM	0:37
Wake times					
T1	49	06:00 AM	10:30 AM	07:28 AM	1:17
T2	49	05:30 AM	07:15 AM	06:35 AM	0:24
T3	51	05:30 AM	07:15 AM	06:35 AM	0:24
Duration					
T1	49	8.75	13.25	10.68	0.96
T2	49	9.00	11.00	10.21	0.54
T3	51	8.75	11.00	10.17	0.54
Nap length					
T1 (full sample)	50	0.00	150.00	17.40	33.38
Children napping at T1	14	30.00	150.00	62.14	34.74
T2 (full sample)	50	0.00	120.00	10.80	24.81
Children napping at T2	10	15.00	120.00	54.00	27.57
Actigraphy					
Onset variability	50	0.10	1.67	0.48	0.33
Duration	50	492.80	631.00	564.01	31.34
Latency	50	3.60	59.60	23.54	11.20
Efficiency	50	63.87	91.17	81.14	4.95
Outcomes					
WJ	49	416.00	503.5	445.28	16.57
Cooperation	47	1.43	3.00	2.70	0.44
Independence	47	1.00	3.00	2.54	0.50
Covariates					
Hispanic	51	0.00	1.00	0.51	0.50
SES	48	-2.38	0.93	0.01	0.90
Age	50	4.65	5.96	5.43	0.29
Medication	50	0.00	1.00	0.16	0.31
WJ PV	50	452.00	513.00	473.26	11.36

Note. Parent reported durations are in hours. Nap lengths are in minutes. WJ = WJ-III composite of Applied Problems and Passage Comprehension subtests W scores. SES = Socioeconomic status. WJ PV = WJ-III Picture Vocabulary subtest W score.

Table 2.

Correlations amongst all the sleep variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bedtime																			
1. T1																			
2. T2	0.62***																		
3. T3	0.56***	0.76***																	
Wake time																			
4. T1	0.69***	0.45***	0.40**																
5. T2	0.14	0.37**	0.32*	0.19															
6. T3	0.19	0.36*	0.51***	0.10	0.67***														
Duration																			
7. T1	-0.24†	-0.12	-0.12	0.54***	0.09	-0.09													
8. T2	-0.51***	-0.70***	-0.50***	-0.30*	0.40**	0.16	0.19												
9. T3	-0.46***	-0.55***	-0.76***	-0.35*	0.17	0.18	0.07	0.67***											
Nap length																			
10. T1	-0.07	0.12	0.04	-0.03	0.11	0.07	0.04	-0.03	0.01										
11. T2	0.59***	0.34*	0.29*	0.53***	0.05	0.05	0.02	-0.30*	-0.28*	0.13									
Change T1-T2																			
12. Bedtime	0.00	0.78***	0.52***	0.03	0.37**	0.30*	0.04	-0.50***	-0.34*	0.20	-0.03								
13. Wake time	0.01	0.29*	0.25†	0.00	0.98***	0.66***	-0.01	0.46***	0.24†	0.12	-0.05	0.37**							
14. Duration	-0.47***	-0.69***	-0.49***	-0.41**	0.39**	0.18	0.00	0.98***	0.67***	-0.03	-0.31*	-0.51***	0.47***						
15. Nap length	0.61***	0.33*	0.29*	0.54***	0.04	0.05	0.01	-0.30*	-0.29*	0.00	0.99***	-0.06	-0.06	-0.31*					
Actigraphy																			
16. Onset variability	0.17	-0.13	0.09	0.35*	-0.08	-0.03	0.25†	0.08	-0.12	-0.07	0.20	-0.30*	-0.14	0.03	0.21				
17. Duration	-0.17	-0.34*	-0.48***	-0.08	0.05	-0.03	0.09	0.38**	0.53***	-0.06	-0.05	-0.30*	0.07	0.37**	-0.04	0.02			
18. Latency	-0.07	-0.30*	-0.17	0.16	-0.06	0.00	0.28†	0.24†	0.20	0.08	-0.05	-0.32*	-0.09	0.20	-0.06	0.43**	-0.15		
19. Efficiency	0.06	0.10	-0.03	-0.04	0.24	-0.04	-0.11	0.08	0.00	0.07	0.01	0.09	0.25†	0.10	0.00	0.01	0.40**	-0.46***	

Note. $^{***}p$<.001. $^{**}p$<.01. $^{*}p$<.05. †p<.10. Variables 1-15 are parent-reported.

Table 3.

Correlations of sleep predictors with academic achievement and participation outcomes and covariates

	Covariates					Outcomes		
						Academic Achievement	Participation	
	Hispanic	SES	Age	Medication	WJ PV	WJ	Cooperation	Independence
Bedtime								
1. T1	0.40^{**}	-0.39^{**}	-0.17	0.00	-0.07	-0.10	0.16	0.05
2. T2	0.19	-0.24	-0.11	-0.09	-0.01	-0.14	-0.05	-0.19
3. T3	0.20	-0.34^{*}	-0.14	-0.14	-0.16	$-0.27^{\dagger}$	0.08	-0.14
Wake time								
4. T1	0.32^{*}	-0.42^{**}	-0.03	-0.20	-0.23	$-0.25^{\dagger}$	0.22	0.04
5. T2	0.11	-0.03	-0.14	-0.34^{*}	-0.03	0.06	0.14	-0.09
6. T3	0.08	0.02	-0.10	-0.15	0.02	0.00	0.15	-0.16
Duration								
7. T1	-0.04	-0.11	0.15	$-0.26^{\dagger}$	-0.23	-0.23	0.13	0.01
8. T2	-0.11	0.22	0.00	-0.17	-0.01	0.18	0.17	0.12
9. T3	-0.16	0.42^{**}	0.08	0.05	0.19	0.31^{*}	0.02	0.03
Nap length								
10. T1	0.00	-0.04	0.08	-0.11	0.02	-0.07	$-0.25^{\dagger}$	$-0.25^{\dagger}$
11. T2	$0.27^{\dagger}$	-0.67^{***}	-0.06	-0.12	-0.32^{*}	-0.37^{**}	0.17	-0.06
Change T1-T2								
12. Bedtime	-0.08	0.00	-0.01	-0.12	0.04	-0.11	-0.16	$-0.25^{\dagger}$
13. Wake time	0.05	0.05	-0.14	-0.31^{*}	0.02	0.10	0.11	-0.10
14. Duration	-0.10	0.24	-0.03	-0.13	0.04	0.23	0.15	0.12
15. Nap length	$0.27^{\dagger}$	-0.67^{***}	-0.07	-0.11	-0.33^{*}	-0.37^{**}	0.21	-0.03
Actigraphy								
16. Onset variability	$0.25^{\dagger}$	-0.18	0.22	0.15	-0.16	-0.15	0.20	0.32^{*}
17. Duration	-0.02	0.19	-0.14	0.18	0.00	0.14	-0.03	0.18
18. Latency	-0.15	0.04	0.21	-0.09	0.23	$0.26^{\dagger}$	0.31^{*}	$0.28^{\dagger}$
19. Efficiency	0.14	-0.06	-0.19	-0.08	-0.24	-0.07	-0.21	-0.06

Note. $^{***}p<.001$. $^{**}p<.01$. $^{*}p<.05$. $^{\dagger}p<.10$. Variables 1-15 are parent-reported. WJ=WJ-III composite of Applied Problems and Passage Comprehension subtests W scores. SES=Socioeconomic status. WJ PV=WJ-III Picture Vocabulary subtest W score. Change T1-T2 variables were standardized residual change scores calculated from a regression predicting the T2 sleep schedule variable from the T1 sleep schedule variable.

Table 4.
Summary of repeated measures ANOVAs

	Multivariate tests		Pairwise comparisons		
	F	df	T1-T2 Δ*M* (*SE*)	T1-T3 Δ*M* (*SE*)	T2-T3 Δ*M* (*SE*)
Bedtime	5.74**	2, 47	25.61**(7.63)	26.55**(7.95)	0.94(3.32)
Wake time	12.14**	2, 47	53.84**(10.93)	55.45**(11.22)	1.61(2.90)
Duration	5.30**	2, 47	28.22**(8.67)	28.90**(9.12)	0.67(3.69)

Note. **p<.01. *p<.05. Bedtimes, wake times, and durations are all in minutes. $N = 44$.

Table 5.

Regressions predicting academic achievement and participation from pre-kindergarten parent-reported sleep schedules

	Academic Achievement			Participation					
	WJ			Cooperation			Independence		
	β	*SE*	ΔR^2	β	*SE*	ΔR^2	β	*SE*	ΔR^2
Bedtime									
Hispanic	0.13	4.30		-0.49^{**}	0.14		$-0.35^{\dagger}$	0.17	
SES	0.10	2.97		-0.05	0.10		0.07	0.12	
Age	-0.09	6.63		0.09	0.22		0.34^{*}	0.26	
Medication	-0.13	6.22		-0.11	0.21		-0.07	0.25	
WJ PV	0.73^{***}	0.21		-0.01	0.01		0.03	0.01	
T1 bedtime	-0.02	0.03	0.00	0.24	0.00	0.05	0.13	0.00	0.01
Wake time									
Hispanic	0.16	4.09		-0.45^{**}	0.14		$-0.31^{\dagger}$	0.16	
SES	0.09	2.80		-0.08	0.10		0.05	0.12	
Age	-0.09	6.36		0.04	0.22		0.32^{*}	0.26	
Medication	-0.14	6.22		-0.04	0.22		-0.05	0.26	
WJ PV	0.72^{***}	0.20		0.08	0.01		0.07	0.01	
T1 wake time	-0.11	0.03	0.10	0.23	0.00	0.04	0.08	0.00	0.01
Duration									
Hispanic	0.12	3.94		-0.40^{*}	0.14		$-0.30^{\dagger}$	0.16	
SES	0.13	2.79		-0.09	0.10		0.05	0.12	
Age	-0.06	6.59		0.05	0.23		0.33^{*}	0.26	
Medication	-0.16	6.34		-0.08	0.23		-0.07	0.27	
WJ PV	0.68^{***}	0.21		0.07	0.01		0.05	0.01	
T1 duration	-0.13	0.04	0.01	0.08	0.00	0.00	-0.02	0.00	0.00
Nap length									
Hispanic	0.11	3.95		-0.42^{*}	0.13		$-0.31^{\dagger}$	0.15	
SES	0.15	2.68		-0.08	0.10		0.05	0.11	
Age	-0.09	6.46		0.09	0.21		0.35^{*}	0.25	
Medication	-0.12	6.24		-0.13	0.21		-0.09	0.24	
WJ PV	0.70^{***}	0.20		0.04	0.01		0.05	0.01	
T1 nap length	0.03	2.42	0.00	$-0.27^{\dagger}$	0.08	$0.07^{\dagger}$	-0.22	0.09	0.05

Note. $^{**}p<.01$. $^{*}p<.05$. $^{\dagger}p<.10$. Hispanic coded 0= non-Hispanic, 1= Hispanic. Age is in years. Medication is a percentage of days the participants took potentially sleep altering medication during the week of actigraph data collection. Duration, wake time, and nap length are all measured in minutes. T1 and T2 nap length were log transformed because of high skew and kurtosis. *N*=43 with WJ as an outcome. *N*=41 with Cooperation and Independence as an outcome.

Table 6.

Regressions predicting academic achievement and participation from changes in parent-reported sleep schedules from pre-kindergarten to the fall of kindergarten

	Academic Achievement			Participation					
	WJ			Cooperation			Independence		
	β	*SE*	ΔR^2	β	*SE*	ΔR^2	β	*SE*	ΔR^2
Bedtime									
Hispanic	0.12	3.95		-0.42*	0.13		-0.32*	0.15	
SES	0.10	2.76		-0.09	0.10		0.03	0.11	
Age	-0.09	6.36		0.05	0.22		0.31*	0.25	
Medication	-0.14	6.18		-0.13	0.21		-0.11	0.24	
WJ PV	0.74***	0.20		0.07	0.01		0.10	0.01	
Δ bedtime	-0.10	0.07	0.10	-0.18	0.00	0.03	-0.28†	0.00	0.08†
Wake time									
Hispanic	0.12	4.00		-0.43*	0.14		-0.30†	0.16	
SES	0.11	2.79		-0.08	0.10		0.05	0.12	
Age	-0.08	6.52		0.09	0.22		0.32*	0.26	
Medication	-0.11	6.58		-0.06	0.22		-0.06	0.26	
WJ PV	0.72***	0.20		0.02	0.01		0.06	0.01	
Δ wake time	0.05	0.08	0.00	0.14	0.00	0.02	0.01	0.00	0.00
Duration									
Hispanic	0.13	3.91		-0.42*	0.13		-0.31†	0.16	
SES	0.07	2.81		-0.10	0.10		0.03	0.11	
Age	-0.09	6.31		0.08	0.22		0.34*	0.25	
Medication	-0.10	6.19		-0.08	0.21		-0.04	0.24	
WJ PV	0.74***	0.20		0.05	0.01		0.06	0.01	
Δ duration	0.14	0.06	0.02	0.18	0.00	0.03	0.22	0.00	0.05
Nap length									
Hispanic	0.12	3.92		-0.42*	0.14		-0.30†	0.16	
SES	0.08	3.23		0.05	0.12		0.07	0.14	
Age	-0.09	6.38		0.07	0.22		0.32*	0.26	
Medication	-0.11	6.19		-0.10	0.21		-0.07	0.25	
WJ PV	0.70***	0.20		0.05	0.01		0.06	0.01	
Δ nap length	-0.11	3.85	0.01	0.20	0.14	0.02	0.03	0.17	0.00

Note. $^{**}p<.01$. $^{*}p<.05$. $^{\dagger}p<.10$. Hispanic coded 0= non-Hispanic, 1= Hispanic. Age is in years. Medication is a percentage of days the participants took potentially sleep altering medication during the week of actigraph data collection. Duration, wake time, and nap length are all measured in minutes. T1 and T2 nap length were log transformed because of high skew and kurtosis. Δ= Residualized change in the specified variable from T1 to T2. *N*=43 with WJ as an outcome. *N*=41 with Cooperation and Independence as an outcome.

Table 7.

Regressions predicting academic achievement and participation from actigraphy

	Academic Achievement			Participation					
	WJ			Cooperation			Independence		
	β	*SE*	ΔR^2	β	*SE*	ΔR^2	β	*SE*	ΔR^2
Onset Variability									
Hispanic	0.11	3.95		-0.50^{**}	0.13		-0.39^{*}	0.14	
SES	0.15	2.65		-0.05	0.09		0.08	0.10	
Age	-0.07	6.55		-0.04	0.21		0.20	0.24	
Medication	-0.10	5.97		-0.10	0.19		-0.07	0.21	
WJ PV	0.69^{***}	0.19		0.07	0.01		0.10	0.01	
Onset variability	-0.04	5.80	0.00	0.37^{*}	0.21	0.11^{*}	0.41^{**}	0.23	0.14^{**}
Duration									
Hispanic	0.10	3.77		-0.42^{*}	0.13		-0.31^{*}	0.15	
SES	0.12	2.66		-0.07	0.10		0.00	0.11	
Age	-0.06	6.23		0.08	0.22		0.37^{*}	0.24	
Medication	-0.13	5.86		-0.08	0.21		-0.10	0.23	
WJ PV	0.71^{***}	0.19		0.03	0.01		0.09	0.01	
Duration	0.13	0.06	0.02	0.04	0.00	0.00	0.31^{*}	0.00	0.09^{*}
Latency									
Hispanic	0.10	3.81		-0.43^{**}	0.13		$-0.31^{\dagger}$	0.15	
SES	0.16	2.62		-0.05	0.09		0.07	0.11	
Age	-0.09	6.40		0.03	0.21		$0.30^{\dagger}$	0.25	
Medication	-0.10	5.97		-0.02	0.20		-0.01	0.24	
WJ PV	0.67^{***}	0.20		-0.05	0.01		0.00	0.01	
Latency	0.07	0.17	0.00	0.26	0.01	0.06	0.16	0.01	0.02
Efficiency									
Hispanic	0.09	3.79		-0.42^{*}	0.13		-0.32^{*}	0.15	
SES	0.14	2.61		-0.07	0.10		0.05	0.11	
Age	-0.07	6.22		0.07	0.22		0.34^{*}	0.25	
Medication	-0.11	5.80		-0.08	0.20		-0.05	0.24	
WJ PV	0.72^{***}	0.20		0.02	0.01		0.07	0.01	
Efficiency	0.12	0.39	0.01	-0.02	0.01	0.00	0.12	0.02	0.01

Note. $^{**}p$<.01. $^{*}p$<.05. $^{\dagger}p$<.10. Hispanic coded 0= non-Hispanic, 1= Hispanic. Age is in years. Medication is a percentage of days the participants took potentially sleep altering medication during the week of actigraph data collection. *N*=45 with WJ as an outcome. *N*=42 with Cooperation and Independence as an outcome.

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APPENDIX A

MEASURE USED TO QUANTIFY SLEEP SCHEDULES ACROSS THE TTOK

The following questions are about your child's sleep habits. When we say "nap" we mean anytime your child fell asleep for 15 or more minutes that was not during his or her usually scheduled bedtime at night.

Choose "I Don't Remember" when you do not know the answer.

Please think about the MONTH BEFORE your child entered Kindergarten when answering the following question(s)…

1. Was your child napping during the day? (If NO, skip to question 2)

O Yes O No

a. How many times a week was your child napping?

1	2	3	4	5	6	7+
O	O	O	O	O	O	O

b. How long was your child typical nap? (m = minutes; h = hours)

Unsure of Duration (e.g., my child was napping in childcare)	O
15 m	O
30 m	O
45 m	O
1 h	O
Longer than 1 h	O

If longer than 1 h please write your child's typical nap length: _________

2. What time did your child usually fall asleep prior to entering Kindergarten?

________________ Please indicate AM or PM

3. What time did your child's usually wake up prior to entering Kindergarten?

________________ Please indicate AM or PM

Please think about the PAST 2 WEEKS when answering the following question(s)…

4. Does your child currently nap (after school or on weekends)? (If NO, skip to question 5)
O Yes O No
a. If yes, how many times a ***week*** does your child nap?

1	2	3	4	5	6	7+
O	O	O	O	O	O	O

b. How long ***is*** your child ***typical*** nap? (m = minutes; h = hours)

Unsure of Duration (e.g., my child was napping in childcare)	O
15 m	O
30 m	O
45 m	O
1 h	O
Longer than 1 h	O

If longer than 1 h please write your child's typical nap length: _______________

5. What time does your child ***usually*** fall asleep on a school night?
________________ Please indicate AM or PM

6. What time does your child ***usually*** wake up on a school day?
________________ Please indicate AM or PM